NOVA SCOTIA

Environment

GUIDELINES FOR DESIGN AND OPERATION OF BIOMEDICAL INCINERATORS IN NOVA SCOTIA

FORWARD:

These guidelines represent a summary of existing practices and procedures used by Nova Scotia Department of the Environment during permit application reviews. They apply to all biomedical waste incinerators that are completed after 1988. These guidelines also apply to any incinerator which is modified or expanded in a manner which may have a significant effect on air emissions. A permit to construct or install an incinerator can be issued under the Environmental Protection Act when the provisions of these guidelines have been considered and compliance with appropriate standards (under the Canada Clean Air Act) has been achieved.

Revision I
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1. Introduction:

1.1 Authority

The Environmental Protection Act, Section 8 (1)d, states that the Minister may regulate and control the construction, operation and maintenance of water treatment facilities and waste treatment facilities, including waste disposal sites. Permits to install, construct or operate a biomedical incinerator may be issued when the provisions of these guidelines have been considered and compliance has been achieved.

1.2 Intent

These guidelines are intended to familiarize hospital and medical laboratory officials, health care institution representatives, and their consultants with Nova Scotia Department of the Environment's requirements for the approval of the design and installation of biomedical incinerators. They will also provide a more consistent approach towards the minimizing of air emissions from biomedical incineration.

1.3 Scope

These guidelines apply only to incinerators which will handle biomedical waste. See Appendix A for definition and classification of biomedical waste. Guidelines entitled "Guidelines For the Handling and Disposal of Biomedical Wastes From Health Care Facilities and Laboratories" are currently being developed by the Council of Teaching Hospitals. The guidelines will incorporate an approved classification and colour coding system for biomedical wastes.

Innovative ideas in incinerator design that also fulfil the requirements of best practical technology will be given due consideration. The intent of these guidelines is not to hamper improvements in the state-of-the-art design of incineration.

1.4 Provision For Update

As "State of the Art" advances for incineration and practical observations provide more information, these guidelines will be updated accordingly.

2.0 Current Technology in Biomedical Waste Incineration

2.1 The Incineration Process

An incinerator is a furnace in which waste is burned. The waste is usually ignited by an auxiliary fuel burner and the products of the reaction are ash and hot flue gases containing pollutants. The non-homogeneity of biomedical waste, with respect to size, heating value, and moisture content requires special attention.

2.2 Principles of Combustion

The degree of combustion is dependent upon three variables: time, temperature and turbulance.

A minimum temperature is required to volatilize the waste and drive off moisture. Time is required for sufficient mixing of the reactants with air and to complete the reaction. Turbulence is necessary to prevent the stratification of the combustion gases to ensure that reactants come into contact with the air supply and the oxidation reactions proceed to completion.

The specific requirements for complete combustion of refuse are therefore:

1) Air and fuel must be in proper proportion;

2) Air and fuel (especially combustion gases) must be mixed adequately;

3) Temperatures must be high enough to ignite the solid fuel and gaseous components; and

4) Furnace volumes must be great enough as to provide the retention time needed for complete combustion.

Figure (1) illustrates the relationship between amount of air flow and temperature in the combustion process. The combustion gases reach the maximum temperature at 0 percent excess air ("theoretical air" or "stoichiometric" conditions). With less than stoichiometric air, the temperature decreases and combustion is incomplete. With more than stoichiometric air, the temperature decreases because of dilution with excess air. Complete combustion can be achieved by close control of temperatures in the combustion chambers.

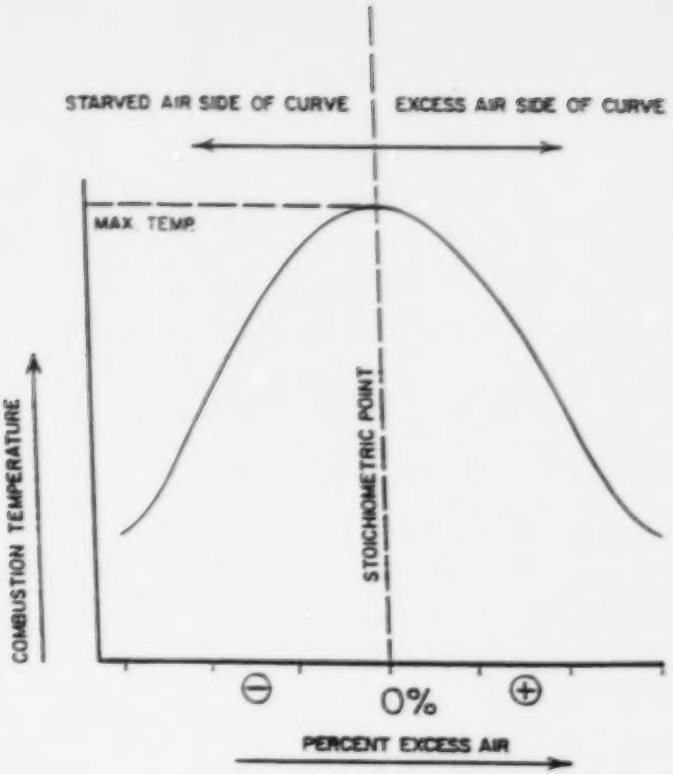

Figure 1 Relationship Between Air Quantity and Temperature

Reference: 10

2.3 Biomedical Waste Incineration

Incineration is especially advantageous with pathological waste and contaminated sharps because it renders body parts unrecognizable and sharps unusable. High temperatures are necessary in order to prevent the release of pathogenic organisms to the environment by way of stack emissions or residue ash. Modern biomedical wastes also contain a high percentage of disposable cellulose and plastic products, which gives biomedical wastes a wide range of higher heating values.

Variation in waste composition, waste feed rate and combustion temperature must all be considered for proper incineration of biomedical wastes.

Waste composition variations in moisture content and heating value affect combustion conditions. It is important to adjust the loading rate and combustion temperature, as required, in order to maintain proper incineration conditions.

Waste feed rate affects the efficiency of incineration. It is very important to avoid overloading, which often results in incomplete combustion and unsatisfactory treatment of infectious waste.

Combustion temperature is important - an optimum temperature must be maintained during combustion to ensure proper treatment of infectious waste. Temperatures can be maintained by adjustments in the amount of combustion air and fuel. Operating temperatures must be attained before loading the waste.

Anti-neoplastic (chemotherapy agents) contaminated waste requires a longer dwell time and higher combustion temperatures. Temperatures of 1000-1100°C (1830 - 2010°F) are required to ensure the complete destruction of these hazardous agents.

Polyvinyl chloride and other plastic materials in the waste can cause excessive surges in temperature due to their high heating value. Chlorinated wastes can also produce harmful combustion products such as hydrochloric acid and chlorinated hydrocarbons.

2.4 Design Characteristics of Biomedical Incinerators

2.4 1) Multiple Chamber Incinerators (Figures 2 & 3):

The biomedical multiple chamber incinerator has a minimum of three chambers, or combustion zones. The primary chamber is equipped with a solid hearth equipped with a lip or trough of about 5 cm. to contain fluids. The hearth may be the hot hearth type constructed of conducting refractory, in order to provide a more complete burn of the low BTU value wastes. If combustion gases are directed under the hearth, it allows for heat transfer to the hearth, which aids combustion in the primary chamber. With the use of a hot hearth, sterilization of the ash is ensured. Generally these incinerators require approximately 300% excess air for good combustion. There are two general designs for multiple chamber incinerators as follows:

a) The retort design is characterized by the arrangement of the chambers which cause the combustion gases to flow through 90° turns in both horizontal and vertical directions. The return flow of the gases permits the use of a common wall between the primary and secondary chambers. Usually this type of multiple chamber incinerator is of smaller capacity (45-450 kg/h). Temperatures of 870°C (1,600°F) are normally achieved in multiple chamber incinerators.

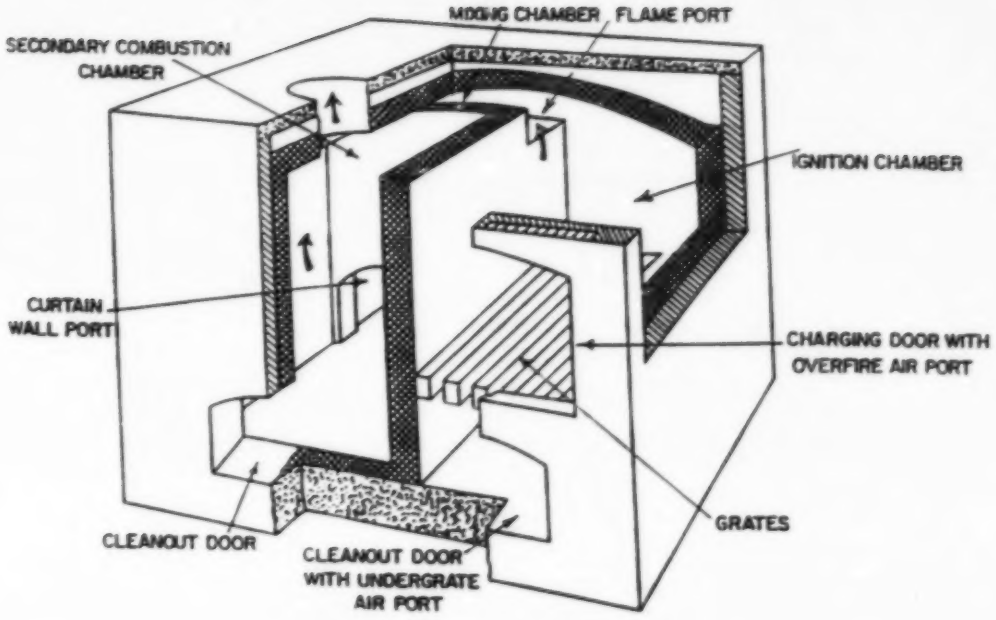

Figure 2 Multiple Chamber Incinerator, Retort Design

Reference: 11

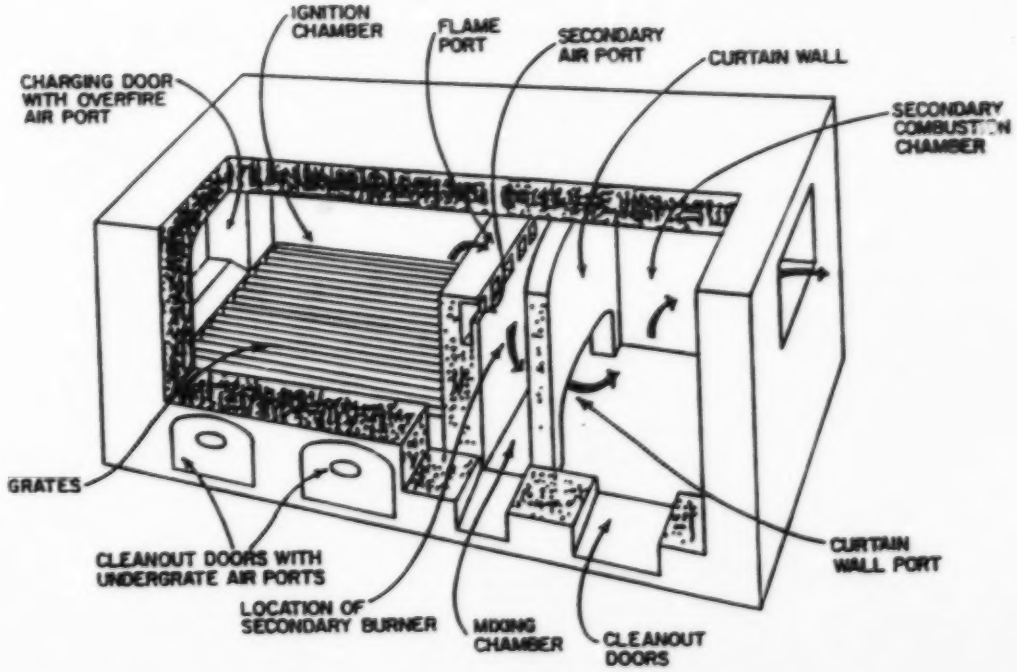

Figure 3 Multiple Chamber Incinerator, In Line Design

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b) The in-line type of incinerator allows the combustion gas to flow straight through the incinerator with 90° turns only in the vertical direction. This type is usually larger and has a grate which makes it unsuitable for liquid waste. However it can be equipped with a separate hot hearth for biomedical waste incineration. The in-line multiple chamber design is in more common use at facilities with large capacity requirements (more than 450 kg/h).

2) **Controlled Air Incinerators** (Figures 4 and 5):

The basic components of controlled air incinerators are the two airtight combustion chambers, the use of afterburners and the inclusion of a stack designed to provide good dispersion of air contaminants in the flue gas. Air flow is automatically regulated, depending upon combustion temperature.

The two major design types are:

a) Starved air units (Figure 4) provide less than theoretical air in the primary chamber (typically 30-80% of stoichiometric air requirements). Pyrolysis gases are formed in the primary chamber. Excess air is provided in the secondary chamber (varies between 40-250% of that required during the peak burning rate) in order to complete combustion [21].

Starved air incinerators are usually batch fed and temperatures in the primary chamber are maintained at about 400-870°C (750-1,600°F) under starved air conditions. In the secondary chamber the resulting highly combustible gases produce temperatures as high as 1,100°C (2,010°F). Retention time for gas phase in the secondary chamber is in the order of 0.5 to over 1.0 second. The auxiliary burner in the secondary combustion chamber maintains the temperature in order to achieve complete combustion. Most of the time the secondary chamber combustion temperatures are self-sustaining, with the auxiliary burner required only on an intermittant basis.

b) Excess air incinerators, (Figure 5) achieve a high combustion rate by the addition of excess air to the primary chamber (typically 60-200% excess air). Excess air incinerators promote almost complete combustion in the primary chamber (approximately 90-95%). Gas-phase combustion is completed in the secondary chamber with additional air as required. Temperatures of 870-980°C (1,600-1,800°F) are maintained in the secondary combustion chambers where auxiliary burners may be used to combust the gases from the primary chamber [21].

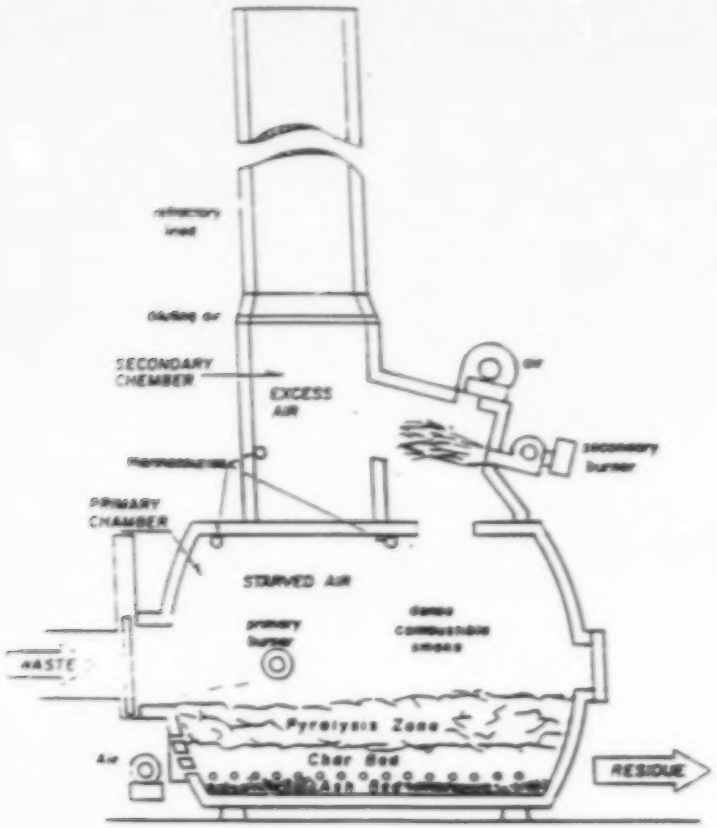

Figure 4 Controlled Air Incinerator, Starved Air Design

Reference: 9

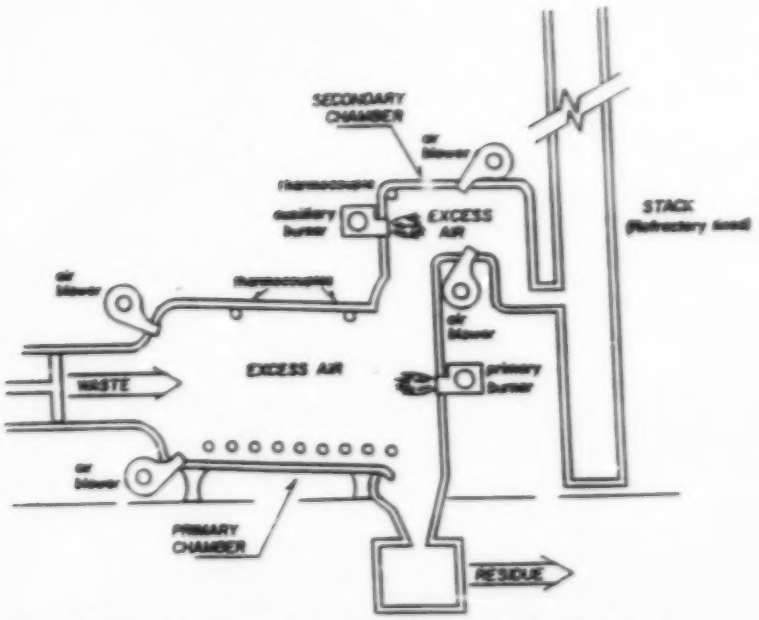

Figure 5 Controlled Air Incinerator, Excess Air Design

2.4 3) **Rotary Kiln Incinerators** (Figure 6):

The rotary kiln is basically a large refractory lined cylindrical shell with an after burner section, mounted on a stand on a slight incline. The entire incinerator rotates slowly and wastes are tumbled along the length of the chamber. As the kiln rotates, the waste burns to ash, which is discharged directly to an ash bin below. Typical operating temperatures range from 800-1,200°C (1,470 - 2,190°F). Higher temperatures may be tolerated because rotary kilns are entirely lined with refractory material.

Rotary kilns may be equipped with a ram feed mechanism or a charging auger. The ram feed may be designed to provide manual feed or a hopper and guillotine door set-up. Normally an auger receives waste from above and waste is gradually compacted as it turns through the tapering auger. This minimizes the potential for burn back into the waste. Auger feed systems would not normally be recommended due to the potential for release of infectious material from containers as they are crushed. A water spray fire protection can also be include to offer additional burn back protection.

Length to diameter (L/D) ratios for rotary kilns range from 2:1 to 10:1, while rotational speeds range from 0.3 to 1.5 meters per minute at the kiln exterior. Speed of rotation can be varied to maintain adequate solids retention time in the kiln to ensure good combustion of waste. Residence times may vary from only a few seconds for gases to a few hours for solids.

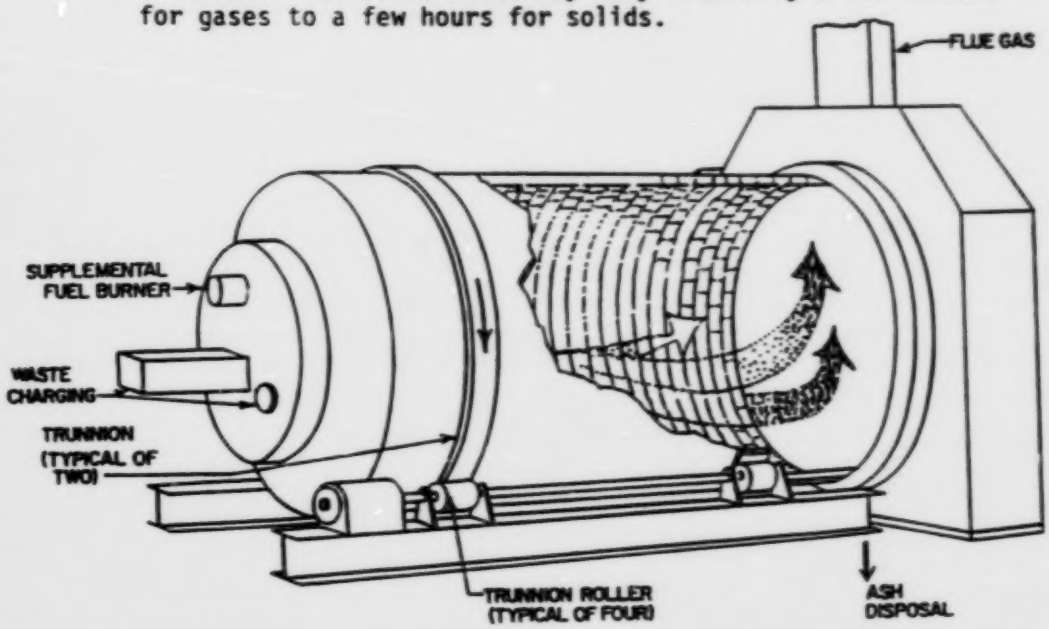

Figure 6 Rotary Kiln Incinerator

2.5 Incinerator Design Comparison:

Multiple chamber incinerators have been widely used for biomedical waste incineration. These units can be operated at sufficiently high temperatures to achieve good burnout of fats and liquids if appropriate containment is achieved. Multiple chambered incinerators may also be run on an intermittant basis, which makes them suitable for the incineration of anatomical and infectious wastes, which are seldom generated in mass quantities.

Combustion air is normally introduced by natural draft and is admitted through manually operated ports. Barometric dampers control the draft and thus, the quantity of air introduced into the incinerator. In order to provide for maximum exposure of waste surface area to the flame, multiple chamber incinerators should be batch fed with small quantities so that the waste is charged across the hearth in a single layer.

When multiple chamber incinerators were used widely in the past for incineration of biomedical wastes, the composition of the wastes was not highly variable. The waste had a low heating value in the range of 2,320 KJ/kg (1,000 BTU) and, therefore, required heavy usage of the auxiliary burners to sustain combustion.

Since the 1970's, characteristics of modern day biomedical wastes have changed dramatically. Present day physical and thermal characteristics have become more complex and these wastes are not easily handled by multiple chambered incinerators. Multiple chambered incinerators are still suitable for burning pathological waste (e.g. animal carcasses) that have a slow heat release and a relatively constant oxygen demand. Most biomedical waste generated today, however, has a much higher heat release rate and a greater oxygen demand fluctuation during incineration because of its variable nature and higher plastics content.

Therefore, in a multiple chamber incinerator, the use of a damper to control airflow is too slow to respond to fluctuating combustion conditions. This leads to either incomplete combustion or run-away conditions. In addition, auxiliary burners are required almost constantly to maintain the temperature of the large amounts of excess air. The multiple chambered incinerator is more costly to operate than controlled air incinerators.

Controlled air incinerators are initially more expensive than multiple chamber incinerators, but they are a state-of-the-art incinerator which can meet the emission standards of most jurisdictions without air pollution control equipment.

The main difference between the controlled air and the multiple chamber incinerator lies in the amount of combustion air and the manner in which the air is admitted. Controlled air incinerators have temperature sensors in the combustion chambers and air flow is temperature regulated automatically. Multiple chamber incinerators use natural draft or air blowers to force excess air, but not in a precisely controlled manner.

Automatic damper positioning is normally used to control the airflow and, therefore, temperature in each chamber in the controlled air incinerator. Temperature control is especially necessary when incinerating non-anatomical biomedical waste, which has a wide variation in composition. The controlled air incinerator is better than the multiple chamber incinerator because it provides higher combustion efficiency, quicker response to temperature fluctuations, and easier operating control.

Rotary kilns have been successfully used at various industrial operations and the technology is especially suitable for a wide variety of liquids and solids. This design is amenable to destruction of some wastes which are difficult to thermally degrade; because temperatures over 1400°C (2550°F) can be achieved. Although the use of rotary kilns for incineration of biomedical waste is quite new, they do offer a potential solution in this area.

One disadvantage of rotary kiln incinerators is the high particulate loading in the flue gas because of the high turbulance created in the combustion chamber. Also there is inherently a lower thermal efficiency because of air leaks via the kiln end seals.

Many controlled air incinerators are "modular" or pre-built at the factory. Components, such as a loading hopper and ash handling system may be installed as required. Combinations of two or more units allow for easy expansion of the system as waste incineration needs grow and provides back-up in the event of breakdowns.

Batch burning units require operator attendance during loading but not during incineration. These units have a limited capacity of usually less than 340 kg/h (750 lb/h) and are usually starved air design.

Continuous charge controlled air units are normally ramcharged continually during the day and are allowed to burn down during the night. There tends to be a better control on the afterburner and air supply because continuous operation makes better use of the heat from the waste. Fuel usage is lessened as a result. The continuous burning and charging also better utilizes the available volume of the unit because volatile gases are released immediately, leaving fixed carbon to burn more slowly.

One disadvantage of controlled air incinerators, besides higher initial capital costs, is the fact that they are complex and require specialized service and repairs.

3. The Preferred Technology:

Generally, controlled air incinerators have improved combustion and therefore reduced air emissions over multiple chamber incinerators. Multiple chamber incinerators may be acceptable in some cases, depending on the waste. Controlled air incinerators are usually considered the best options in regards to air emission levels. In tests conducted by Fisheries and Environment Canada, Environmental Protection Service, controlled air incinerators emitted less combustion related pollutants than the multiple chamber incinerator (see Table 1).

The United States Environmental Protection Agency established emission factors for various incinerator types and air pollutants in 1977. The controlled air incinerators burned the cleanest of all incinerator types tested (see Table 2). The efficient combustion design and the automated operation of controlled air incinerators make these low emission rates possible.

The application of rotary kiln technology for this purpose is still relatively new, and is therefore, less attractive because of lack of operating experience. Based on their performance in other applications, however, rotary kilns offer potential for the efficient incineration of biomedical wastes.

The multiple chamber incinerator, as presently designed, cannot be considered suitable to handle the entire range of biomedical waste currently being generated in health care facilities and medical laboratories. The multiple chamber incinerator may still be useful for the destruction of waste with little variation in composition, such as anatomical waste.

TABLE 1

EMISSIONS FROM PACKAGED INCINERATORS *

Pollutant	Controlled Air (g/kg)	Multiple Chamber (g/kg)	Single Chamber (g/kg)
Particulate Matter (dry filterable)	0.6	1.2	7.7
Particulate Matter (condensible)	0.3	1.0	4.2
Particulate Matter (total)	0.9	2.2	11.9
Carbon Monoxide	Neg.	1.8	99 to 496
Organic Acid (acetic)	N.A.	0.4	<2
Aldehydes (formaldehyde)	N.A.	0.09	3 to 32
Hydrocarbons (methane)	Neg.	<0.5	N.A.
Nitrogen Oxides	1.6	1.1	<0.05

* NOTE: These figures are for incinerators burning refuse, not biomedical waste.

Neg. - Negligible

N.A. - Not Available

Reference: 11

[redacted] U.S. [redacted] P. [redacted] INC[redacted]ATO[redacted]MIS[redacted] FA[redacted]S ([redacted]

(From "Compilation of Air Pollutant Emission Factor", Including Supplements 1-12, Third Edition, U.S. E.P.A. Office of Air Quality Planning and Standards 1977)

				Domestic, Single Chamber			Multiple Chamber		
	Trench M.S.W.	Flue Fed Single	Flue Fed Modified*	Without Primary Burner	With Primary Burner	Path.	Uncontrolled/Controlled		Controlled Air
Particulate	18.5	5.0	3.0	17.5	3.5	4	15	7.0	0.7
SO_2	1.25	0.25	0.25	0.25	0.25	Neg.	1.25	1.25	0.75
NO_2	N/A	1.5	5.0	0.5	1.0	1.5	1.5	1.5	5.0
CO	N/A	10.0	5.0	150.	Neg.	Neg.	17.5	17.5	Neg.
Metals									
Organics (Methane)		7.5	1.5	50.0	1.0	Neg.	.75	.75	Neg.

* NOTE: Most of these figures are for refuse burning incinerators, not biomedical. The "path" incinerator is most likely a multiple chamber incinerator, the exact nature of waste was not given.

* With afterburners and draft controls -

Reference: 25

4. GENERAL REQUIREMENTS FOR BIOMEDICAL INCINERATORS IN NOVA SCOTIA

A) Permits and Codes:

1. A permit to operate must be obtained from the Nova Scotia Department of the Environment prior to construction of a new incinerator;

2. Approval for any alterations or changes to a new or existing incinerator which may affect emissions must be obtained from the Nova Scotia Department of the Environment;

3. All incinerators operated in Nova Scotia must be designed and sized in accordance with accepted engineering practices. Any incinerator design to be used requires an engineering stamp. All components and sub-systems which make-up the incinerator must meet or exceed the applicable Nova Scotian and Canadian Regulations, Standards and Codes;

4. Controlled air incinerators may be approved for use in all areas of Nova Scotia subject to any local municipal restrictions that may apply;

5. Flue fed and chute fed incinerators shall not be operated in Nova Scotia;

6. Auxiliary burners installed on incinerators shall comply with regulations established by Nova Scotia Department of Labour Standard: "Installation Code for Oil Burning Equipment" (CSA B-139) and "Propane Installation Code" (CAN/CGA-B149.2-M86);

7. If the incinerator is installed in a room, the room shall conform to "The Nova Scotia Provincial Building Code". The incinerator room must be provided with an adequate air supply to ensure proper combustion;

8. All incinerators shall be lined with an appropriate refractory material that meets pertinent ASTM Standards;

9. Only the most efficient incinerator designs may be used for biomedical wastes. Specific requirements will be prepared and provided on a case by case basis, upon request;

10. CSA Standard Z317.10 - M1981, "Handling of Waste Materials Within Health Care Facilities" or applicable Provincial Guidelines or Regulations should be followed;

11. An approved site for incinerator ash disposal must be available prior to installation or operation of a new incinerator.

B) **Design Criteria:**

General:

1. The type and size of a biomedical incinerator should be adequate to efficiently process the quality and quantity of waste that may be expected; while at the same time limiting the discharge of contaminants to the ambient air;

2. It is recommended that each facility review and document its own practice in order to accurately determine its waste generation rate;

3. All incinerators should be provided with an identification plate, permanently attached in an obvious and accessible location. The plate shall bear the manufacturer's name, model number, capacity rating and auxiliary fuel burner ratings;

4. Incinerators should be equipped with auxiliary burners and be sized to suit the type of refuse being burned;

5. Dampers or positive manual draft controls should be provided on all incinerators. Automatic draft control may be required;

6. Clean-out doors or entrances should be provided so that all parts of the incinerator, including air nozzles, may be cleaned;

7. Incinerators should be designed to minimize the possibility of overloading;

Feed System:

8. All feed systems should be designed to prevent the leakage of liquids that may be contained in the waste and should be sloped towards the opening of the incinerator;

9. When a mechanical feed system is employed, provisions should be made to ensure that the hopper sides and containers are disinfected on a regular basis. All cleaning fluids and wastes should be drained to a controlled area or proper container and then properly disposed of;

10. Mechanical feed systems should be interlocked with the air pollution monitoring equipment to facilitate lock-out of the waste feed if the temperature in the secondary chamber falls below 1,000°C (1,830°F) or, if there is a failure in the pollution control equipment;

11. Automated mechanical feed systems are desirable to maintain steady operation;

Primary Chamber:

12. The primary chamber should be sized to accommodate the variation in the waste composition;

13. The volume of the primary chamber should be designed to allow for a total heat release rate of between 445,000 $kj/h/m^3$ (13,000 $BTU/hr/ft^3$) and 930,000 $kj/h/m^3$ (25,000 $BTU/hr/ft^3$);

14. The hearth area should be designed to allow a burning rate of 58.5 - 68.5 $kg/h/m^2$ (12-14 $lb/hr/ft^2$);

15. The primary chamber should be designed to operate continuously under negative pressure to prevent fugitive emissions;

16. Temperature in the primary chamber should be maintained at no less then 760°C (1400°F);

17. The primary chamber hearth should have an adequate grease containment lip (of at least 5 cm) at the opening to prevent escape or leakage of fluids from the chamber;

Secondary Chamber:

18. The temperature in the secondary chamber should be designed for a minimum of 1,100°C (2,010°F), with an operating temperature of not less than 1,000°C (1,830°F) at all times;

19. The incinerator should be designed to provide no less than 6% residual oxygen in the flue gas exhaust from the secondary chamber;

20. The secondary chamber should be designed for a gas residence time of not less than one second at 1,000°C (1,830°F);

21. Temperature in the secondary chamber should be controlled by a thermocouple or other temperature sensor located at a point representing one second retention time at the breeching. The thermocouple should be connected to a system to provide automatic temperature control and it should also regulate the modulating secondary chamber burner;

Combustion Requirements:

22. Gas turbulence is an important factor in the design of incinerators and can be achieved by high combustion gas velocity, tangential air injection, abrupt changes in flow direction, and the installation of combustion gas restrictions (e.g. orifices, baffles, or checkerwork);

23. For starved air incinerators, air to the primary chamber should be supplied at 40 - 80% of that required for stoichiometric combustion;

24. The air supply in the secondary chamber of all incinerators shall be able to provide excess air at 40 - 250% of that theoretically required during the peak burning rate;

25. The combustion air supply should be automatically adjustable with a Temperature Recorder Control (TRC) System to maintain the set temperatures in the primary and secondary chambers of the incinerator;

Burners:

26. The burners should be able to maintain a stable flame throughout the range of pressures, input rates, and fuel/air ratios experienced in the primary and secondary chambers;

27. The burners should be designed to supply a minimum of 80% of the total heat input of the incinerator design capacity. The burners must also be capable of modulating down to 15% of the total heat input requirements;

28. The burners of the primary chamber should be:

    - located at a downward angle to provide maximum impingement of the flame onto the wastes. The alignment of the burner(s) shall not allow the flame to impinge on the refractory walls or on other burners;

    - set to maintain a temperature of not less than 760°C (1400°F) in the primary chamber once the burn cycle is begun;

    - constructed with a sealed casing to obstruct the flow of tramp air into the chamber;

29. The burners in the secondary chamber should be:

    - mounted in order to provide for thorough mixing throughout the entire chamber. The alignment of the burner(s) shall not allow the flame to impinge on the refractory walls or on the other burner(s);

- designed to automatically lock out the primary chamber charging mechanism in the event of burner(s) failure;

- set to maintain a temperature of not less than 1,000°C (1,830°F) in the secondary chamber at all times;

- fully modulating with a low "hold fire" setting to ensure a flame throughout the incineration cycle;

Process & Emissions Monitoring/Control:

30. Temperature Recorder/Controller (TRC) should be used to control primary and secondary temperatures by:

    - turning off or reducing heat input from the burners;

    - turning off, throttling back or increasing the air supply; and

    - turning on the quench water system, where used;

31. The TRC should provide a graphical recording of the temperature variations and should be calibrated on a regular basis;

32. A TRC should be used to monitor the temperature at the exit of the primary chamber and also control the air supply to the primary chamber and its auxiliary burners. A second TRC should be installed to monitor the temperature at the exit of the secondary chamber or at the base of the stack, and also to control the secondary air supply and its auxiliary burners;

33. Continuous total hydrocarbon or carbon monoxide monitoring equipment may be required for some incinerators;

34. An opacity meter should be provided in the incinerator stack;

35. One, or preferably, two viewports should be installed in the primary chamber immediately behind the burners to facilitate visual inspection of the burn. The location should be selected to minimize particulate impingement so that a clear view is possible;

36. Stack sampling ports may be required in incinerator stacks by the Nova Scotia Department of the Environment;

37. Adequate flue gas scrubbers, flyash collectors, draft gauges, opacity monitors, temperature indicators or other monitors may be required by the Nova Scotia Department of the Environment;

38. All incinerator stacks should be designed to provide:

- adequate draft for proper operation of the incinerator;
- adequate dispersion of all air contaminants to meet acceptable ground level concentrations;
- compliance with "Standard on Incinerators, Waste and Liner Handling Systems and Equipment" (NFPA No. 82-1977); and
- adequate separation distances between the incinerator stack and any building air intakes as determined by the Nova Scotia Provincial Building Code, NFPA No. 82-1977 and proper plume dispersal provisions;

39. The flue of any incinerator unit should not be connected with any other combustion unit stack (e.g. boiler or heater) without specific approval of the Nova Scotia Department of the Environment;

40. For natural draft systems, calculations for stack design should be based at least on a minimum gas temperature of 1,000°C (1,830°F). If substantial heat losses through the stack are expected, such losses should be taken into account in calculating the average stack temperature and the available draft;

41. The stack height should be calculated to provide a minimum available draft of 6.3 mm. (0.25 in) water gauge (W.G.) at the breeching. The latter is an absolute minimum draft provision for all natural draft biomedical waste incinerators. This must result in a draft of at least 2.5 mm (0.1 in) W. G. at the burner air inlets. Perry's Chemical Engineer's Handbook outlines procedures for calculating stack draft;

Quenching:

42. A water quench system may be required in the primary chamber of the incinerator to prevent the temperature from developing into runaway conditions and/or to reduce flue gas temperatures at the exit of the secondary chamber;

43. The quench system should be activated by the primary chamber TRC and sized to reduce the temperature in the primary chamber by 200°C (390°F) within 60 seconds.

C) Operating Criteria:

1. The manufacturer should provide adequate instructions and drawings for operating the incinerator with wastes of the specified categories. The instructions should include the procedures for start-up, normal operation, shut-down, care and maintenance. A copy of the instructions should be posted near the incinerator and should be readily available to the operator;

2. Access to the incinerator and its operation should be restricted to a limited number of individuals with the knowledge and training on the proper procedures to be used as outlined in above;

3. A regular maintenance program should be established for all incinerators. Depending upon the application, a maintenance inspection and thorough cleaning is suggested at least once every six months;

4. Operating personnel should be fully trained by the manufacturer's service technician prior to and during start-up period;

5. The maintenance manual supplied by the manufacturer should include plumbing and wiring diagrams, lubrication and preventive maintenance instructions and a drawing of the incinerator system with all parts identified. The parts list should give part number, name and source of supply;

6. The refractory surface of the secondary chamber should be heated over a minumum period of half an hour, prior to feeding waste into the incinerator;

7. A suitable burndown time should be allowed for all incinerators that do not operate on a continuous 24 hour cycle;

8. Caution should be exercised when removing and disposing of incinerator ash because of the presence of sharps, needles and glass;

9. The incinerator ash should be wetted prior to handling in order to minimize airborne dust;

10. All personnel handling the ash should wear or use dust masks, gloves, and protective clothing as a safety precaution;

11. The incinerator ash should be stored in enclosed containers and transported to an approved landfill site for disposal;

12. To safeguard against accidental incineration of hazardous goods, the waste stream should be closely monitored by operating personnel.

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APPENDIX A

Definition and Classification of Biomedical Waste

For the purposes of these guidelines, "biomedical" waste refers to any anatomical, pathological, infectious, and/or hazardous waste generated in health care facilities and medical laboratories that requires special handling.

Biomedical waste should be segregated and packaged in leakproof, colour coded plastic bags to facilitate identification, handling, storage, decontamination and transportation. A system for Nova Scotia hospitals is presently being developed by the Council of Teaching Hospitals Metropolitan Committee for Hospital Waste Handling and Disposal. The document titled, "Guidelines For The Handling and Disposal of Biomedical Wastes From Health Care Facilities and Laboratories", should be closely followed.

Hospitals are amongst the largest solid waste generators today on a per capita basis. Much of the wastes comes from patient's trash baskets and typically includes reading material and discarded bouquets. As well, discarded masks, splints, gloves, broken syringes and ampoules are also routinely added to the waste stream.

Since the 1970's, the use of disposable or single purpose products has been steadily increasing. These disposable products may include such items as nightgowns, bed pads, sheets, and pillow cases. In some hospitals these items account for almost fifty percent of the quantity of solid waste generated.

Studies have been conducted on waste generation rates in some U.S. hospitals, between 1968-1980. A similar study was carried out at the Royal Jubilee Hospital, Victoria, British Columbia, in 1980, where waste generation rates were reported to fall between 1.5 - 7.5 kg/bed/day. In 1985 Alberta hospitals were surveyed and the waste generation rate was found to be 3.2 - 6.6 kg/bed/day.

In 1985, two surveys conducted in Ontario found that the biomedical waste generation from Ontario hospitals ranged from 2.3 to 7.7 kg/bed/day of biomedical waste and 0.75 kg/day of infectious waste per day for each special care bed.

Medical Laboratories:

Laboratory wastes produced from private and diagnostic laboratories are considered infectious. From another Ontario study it is estimated that approximately 0.2 kg/patient/day is generated from the medical labs.

Medical laboratory wastes contain up to 50-60% plastics, mostly the non-halogenated type. The balance of medical laboratory waste consists of wet materials such as bodily fluids, blood and used diagnostic reagents, and small quantities of paper and cellulose.

In summary, the biomedical waste generation rate varies from facility to facility and is dependent on the use of disposable apparatus and linens. It is, therefore, recommended that each facility accurately determine its waste generation rate and waste characteristics. If this is not possible, Table A1 may be consulted for approximate values, although the figures are derived for use in Ontario.

TABLE A 1

BIOMEDICAL WASTE GENERATION *

Hospitals:

Total Biomedical Waste - 6 kg/bed/day

Special Care Waste - 1 kg/special care bed/day

Medical Laboratories

Total Laboratory Waste - 0.2 kg/patient/day

This includes special care waste, but excludes kitchen waste.

* This table was developed using Ontario figures and may not be applicable to all Nova Scotian health care facilities. Waste generators may be able to use these figures if it is not possible to conduct a waste generation survey.

APPENDIX B

Characterization of Biomedical Waste:

Tables B1 and B2 summarize the properties of the biomedical waste in terms of moisture content, higher heating value, component weight percent and bulk density; in metric and imperial units respectively. These waste classifications are based on the CSA guidelines "Handling of Waste Materials Within Health Care Facilities". The ranges of weight percent are based on field measurements and data provided by various health care facilities. Values in column 7 in each table reflect the weighted HHV range of the waste components (as fired) under each classification and have been calculated from data in columns 3, 4 and 6. Typical values, based on interpretation of actual findings from an Ontario facility, are given the column 8.

Because of the wide range of higher heating value great care must be taken in using the data from this table for the design of a biomedical incinerator. A thorough study of the waste stream should be undertaken to characterize the waste as fully as possible.

A summary of the typical higher heating values for each type of biomedical waste is also given in Tables B1 and B2. Type A, Class 3 wastes (non-anatomical, infected, laboratory wastes, and wastes from DNA work) have higher heating values of 21,000 KJ/kg or greater. The other waste classes, anatomical wastes, all have higher heating values of less than 6,700 KJ/kg.

Blending of these "high and low" higher heating value wastes may achieve a waste which is capable of self-sustaining combustion. The possibility of blending must be evaluated on a case by case basis.

Microbiological Characteristics:

The destruction of micro-organisms within the incinerator depends on temperature and time exposure. Emissions of micro-organisims from an incinerator can result from:

- initial charging of the incinerator before operating temperatures are achieved;
- failure to pre-heat the refractory lining;
- temperature fluctuations caused by intermittent use;
- exceeding design linear velocities, through reducing retention time;
- over-charging;
- excessive moisture content of waste;

Other factors such as type of refractory lining, provision of temperature controlling devices, and the precision of temperature controlling devices, can also have a bearing on the effectiveness of destruction of micro-organisms.

The following recommendations are made by Barbeito(4) to ensure complete sterilization of micro-organisms:

a) Minimum tempertures in the primary and secondary chambers should be maintained at no less than 760°C (1,400°F) and 870°C (1,600°F), respectively;

b) A minimum of one-half hour pre-heat period should be provided for the secondary chamber prior to waste introduction;

c) Only non-infectious waste should be incinerated initially after pre-heating period, if an incinerator is not operated continuously. Infectious wastes should only be charged into the incinerator after the secondary chamber has been on for one-half hour;

d) Each individual incinerator, even of similar models, should be tested with bacterial spores to determine the minimum required temperature to attain complete sterilization;

It is also a good practice to remove the ash on a batch basis, at the end of each cycle (usually 4-6 hours), in order to provide a long solids retention time in the primary chamber. This will also aid in achieving complete destruction of micro-organisms.

TABLE B1

CHARACTERIZATION OF BIOMEDICAL WASTE (Metric Units)

1	2	3	4	5	6	7	8
Waste Class	Component Description	Typical Component Weight Percent (As Fired)	HHV Dry Basis (KJ/kg)	Bulk Density As Fired (kg/m^3)	Moisture Content Of Component (Weight Percent)	Weighted Heat Value Range Of Waste Component (KJ/kg)	Typical Component Heat Value Of Waste As Fired (KJ/kg)
A1	Human Anatomical	95-100	18600-27900	800-1200	70-90	1770[a]-8370[b]	2800
	Plastics	0-5	32500-46400	80-2300	0-1	0-2300	400
	Swabs, Absorbants	0-5	18600-27900	80-1000	0-30	0-1400	200
	Alcohol, Disinfectants	0-0.2	25500-32500	800-1000	0-0.2	0-70	50
							3450
A2	Animal Infected	80-100	20900-37100	500-1300	60-90	1670-14840	3500
	Anatomical						
	Plastics	0-15	32500-46400	80-2300	0-1	0-6960	1000
	Glass	0-5	0	2800-3600	0	0	0
	Beddings, Shavings	0-10	18600-20900	320-730	10-50	0-1880	1400
	Paper, Fecal Matter						5900
A3 (a)	Guaze, Pads, Swabs	60-90	18600-27900	80-1000	0-30	7810-25110	15000
	Garments, Paper						
	Cellulose						
	Plastics, PVC, Syringes	15-30	22500-46400	80-2300	0-1	3340-13920	7540
	Sharps, Needles	4-8	140	7200-8000	0-1	6-10	10
	Fluids, Residuals	2-5	0-23200	1000-1020	80-100	0-230	70
	Alcohols, Disinfectants	0-0.2	16200-32500	800-1000	0-50	0-70	30
							22650

NOTE: 7a (1770 kj/kg) = (0.95 x 18600) (1-0.9)
7b (8370 kj/kg) = (1.0 x 2790) (1-0.7)

1	2	3	4	5	6	7	8
Waste Class	Component Description	Typical Component Weight Percent (As Fired)	HHV Dry Basis (BTU/lb)	Bulk Density As Fired (lb/ft^3)	Moisture Content Of Component (Weight Percent)	Weighted Heat Value Range Of Waste Component (BTU/lb)	Typical Component Heat Value Of Waste As Fired (BTU/lb)
A1	Human Anatomical	95-100	8000-12000	50-75	70-90	760[a]-3600[b]	1200
	Plastic	0-5	14000-20000	5-144	0-1	0-1000	180
	Swabs, Absorbants	0-5	8000-12000	5-62	0-30	0-600	80
	Alcohol, Disinfectants	0-0.2	11000-14000	48-62	0-0.2	0-28	20
							1480
A2	Animal Infected	80-100	9000-16000	30-80	60-90	720-6400	1500
	Anatomical						
	Plastics	0-15	14000-20000	5-144	0-1	0-3000	420
	Glass	0-5	0	175-225	0	0	0
	Bedding, Shavings	0-10	8000- 9000	20-46	10-50	0-810	600
	Paper, Fecal Matter						2520
A3 (a)	Guaze, Pads, Swabs	60-90	8000-12000	5-62	0-30	3360-10800	6400
	Garments, Paper						
	Cellulose			5-144	0-1	1440-6000	3250
	Plastics, PVC, Syringes	15-30	9700-20000	450-500	0-1	3-5	5
	Sharps, Needles	4-8	60	62-63	80-100	0-11	30
	Fluids, Residuals	2-5	0-10000	48-62	0-50	0-28	15
	Alcohols, Disinfectants	0-0.2	7000-14000				9700

NOTE: 7(a) (760 BTU/lb) = (0.95) (8000) (1-0.9)
7(b) (3600 BTU/lb) = (0.95) (12000) (1-0.7)

CHARACTERIZATION OF BIOMEDICAL WASTE (Metric Units)

1	2	3	4	5	6	7	8
Waste Class	Component Description	Typical Component Weight Percent (As Fired)	HHV Dry Basis (KJ/kg)	Bulk Density As Fired (kg/m^3)	Moisture Content Of Component (Weight Percent)	Weighted Heat Value Range Of Waste Component (KJ/kg)	Typical Component Heat Value Of Waste As Fired (KJ/kg)
A3 (b)	Plastics	50-60	32500-46400	80-2300	0-1	16090-27840	21000
	Sharps	0-5	140	7200-8000	0-1	0-10	0
Lab Waste	Cellulosic Materials	5-10	18600-27900	80-1000	0-15	790- 2790	1500
	Fluids, Residuals	1-20	0-23200	1000-1020	95-100	0-230	70
	Alcohols, Disinfectants	0-0.2	25500-32500	800-1000	0-50	0-70	50
	Glass	15-25	0	2800-3600	0	0	0
							22620
A3 (c)	Gauze, Pads, Swabs	5-30	18600-27900	80-1000	0-30	650- 8370	2300
	Plastics, Petri Dishes	50-60	32500-46400	80-2300	0-1	16090-27840	21000
R & D	Sharps, Glass	0-10	140	7200-8000	0-1	0-10	0
on DNA	Fluids	1-10	0-23200	1000-1020	80-100	0-460	230
							23530
B1	Non-Infected Animal Anatomical						
90-100	20900-37100	500-1300	60-90	1880-14840	3000		
	Plastics	0-10	32500-46400	80-2300	0-1	0- 4640	2300
	Glass	0-3	0	2800-3600	0	0	0
	Bedding, Shavings Fecal Matter	0-10	18600-20900	320- 730	10-50	0- 1880	1400
							6700

Reference: 22

TABLE 6E

CHARACTERIZATION OF BIOMEDICAL WASTE (Imperial Units)

1	2	3	4	5	6	7	8
Waste Class	Component Description	Typical Component Weight Percent (As Fired)	HHV Dry Basis (BTU/lb)	Bulk Density As Fired (lb/ft^3)	Moisture Content Of Component (Weight Percent)	Weighted Heat Value Range Of Waste Component (BTU/lb)	Typical Component Heat Value Of Waste As Fired (BTU/lb)
A3 (b)	Plastics	50-60	14000-20000	5-144	0-1	6930-12000	9000
	Sharps	0-5	60	450-500	0-1	0-3	0
Lab Waste	Cellulosic Materials	5-10	8000-12000	5-62	0-15	340-1200	650
	Fluids, Residuals	1-20	0-10000	62-63	95-100	0-100	30
	Alcohols, Disinfectants	0-0.2	11000-14000	46-62	0-50	0-28	20
	Glass	15-25	0	175-225	0	0	0
							9700
A3 (c)	Gauze, Pads, Swabs	5-30	8000-12000	5-62	0-30	200-3600	1000
	Pastics, Petri Dishes	50-60	14000-20000	5-144	0-1	6930-12000	9000
R & D	Sharps, Glass	0-10	60	450-500	0-1	0-6	0
on DNA	Fluids	1-10	0-10000	62-63	80-100	0-200	100
							10100
B1	Non-Infected Animal Anatomical	90-100	9000-16000	30-80	60-90	810-6400	1400
	Plastics	0-10	14000-20000	5-144	0-1	0-2000	1000
	Glass	0-3	0	173-223	0	0	0
	Beddings, Shavings	0-10	8000-9000	20-46	10-50	0-810	600
	Fecal Matter						3000

Reference: 22

APPENDIX C

INCINERATION TERMINOLOGY AND DEFINITIONS

In these guidelines:

"air contaminant" means any solid, liquid or gas, or combination of any of them in the atmosphere, which results directly or indirectly from the activities of man;

"auxiliary fuel" means a fuel burned to assist the combustion process for the purpose of preheating the incinerator or drying and igniting the solid waste and maintaining adequate temperatures or any combination thereof when waste combustion is not self-supporting [7];

"burnout" means the effective completion of combustion of the charged waste in the incinerator;

"controlled air incinerator" means an incinerator with an airtight ignition chamber, an after-burner chamber and a controlled draft. A controlled air incinerator is either an excess air incinerator or a starved air incinerator;

"damper" means a manual or automatic device used to regulate the rate of flow of gases through the incinerator;

"draft" means the difference in static pressure between the incinerator chamber and the atmosphere. The resulting flow or draft is positive when the chamber pressure is above atmospheric pressure, and negative when it is below atmospheric pressure;

"multiple chamber incinerator" means an incinerator consisting of three refractory lined chambers or zones connected by gas passages, or ducts, and designed in such a manner as to provide both overfire and underfire combustion air;

"new incinerator" means any incinerator installed during or after 1988.

"operator" means the incinerator owner or agent of the owner having responsibility for the management of the incinerator;

"particulate matter" means any material, except uncombined water, having definite physical boundaries at reference conditions;

"residence time" means the average time spent by gaseous products of combustion in the incinerator;

"scrubber" means auxiliary equipment designed to remove air contaminants from the products of combustion;

"stoichiometric" means the exact amount of air required to supply oxygen for complete combustion of a given quantity off a specific fuel;

"visible emission" means any air contaminants which, when emitted into the atmosphere, can be detected by an observer but does not include an open smokeless flame;

"waste" means any discarded or otherwise unwanted material predominantly composed of one or more of the materials classified in Appendix B.